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A CONTRIBUTION TO DRINKING WATER SOURCES PROTECTION STRATEGIES IN A PORTUGUESE RIVER BASIN

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INTRODUCTION

The river Cavado basin, located in the north-western region of Portugal (Figure 1), has a very intensive use for water supply, irrigation and hydropower generation.

New water supply project serving the Oporto Metropolitan Area, with one million people and a design flow of 2.7 m³/s, will introduce new challenges in the river water quality management. Since the river Cavado flow regime is artificially controlled by reservoirs, a flow discharge policy is needed. Moreover, the consideration of wastewater loads in the basin – wastewater treatment plant (WWTP) effluent discharges, untreated industrial wastewater discharges and agricultural diffuse pollution – must be considered to allow adequate river water quality for drinking water supply purposes.

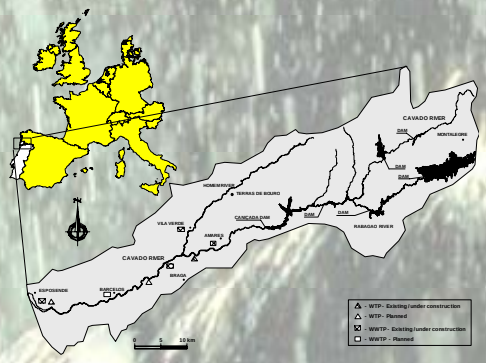

Figure 1 - General Layout of the River Cavado Basin

METHODOLOGY

Decision support systems (DSS) provide new attractive tools to support river basin management, incorporating data base management, hydrologic, hydrodynamics, ecological modelling and geographic information systems. The application of this methodology considering various planning scenarios, in order to establish operational standards at the new water treatment plant (WTP), is summarised in Figure 2 (Vieira, 1999).

The study area includes the lower level part of the basin (48 km river length), where the main residential and industrial zones are located. Due to the river basin hydromorphological characteristics, six large hydropower plants are in operation, representing a high regulatory capacity for river flows. In order to satisfy the needs of potable water supply, a strategy for flow regulation was worked out considering four operational regimes (A, B, C, D) at Caniçada hydropower system, simulating hourly variations in a large range of typical work situations (Figure 3).

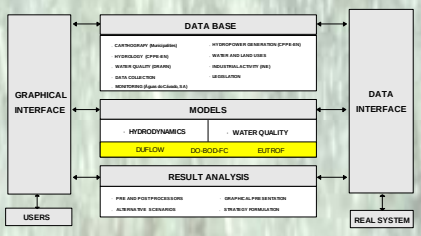

Figure 2 - DSS Application for River Cavado Basin

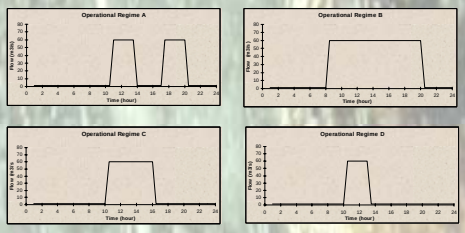

Figure 3 - Operational Regimes at Caniçada Hydropower System

Table 1 - Scenarios for DO, BOD, FC and Eutrophication

Braga WWTP efficiency	Q_{abs} (m³/s)	Q_{pp}= 8 m³/s	Q_{pp}= 16 m³/s	Q_{pp}= 45 m³/s
0%	0	S 1	S 2	S 3
	2	S 4	S 5	S 6
	4	S 7	S 8	S 9
60%	0	S 10	S 11	S 12
	2	S 13	S 14	S 15
	4	S 16	S 17	S 18
90%	0	S 19	S 20	S 21
	2	S 22	S 23	S 24
	4	S 25	S 26	S 27

Light energy (W.m⁻²)	Water Temperature (°C)	Q_{pp} = 8 m³/s	Q_{pp} = 16 m³/s	Q_{pp} = 45 m³/s
150	15	ES 1	ES 5	ES 9
	25	ES 2	ES 6	ES 10
300	15	ES 3	ES 7	ES1 1
	25	ES 4	ES 8	ES 12

Mathematical models have been applied for a range of river flow conditions to predict water quality changes due to pollutant discharges. Biochemical oxygen demand (BOD), dissolved oxygen (DO), faecal coliforms bacteria (FC), nutrients (N and P) and *chlorophyll-a* (Chl-a) were used as water quality control parameters to assess critical situations near the proposed abstraction point of Areias de Vilar. The river water quality was simulated for different scenarios (Table 1), considering Braga WWTP efficiency, abstracted water flow at planned WTP site, river flow at Ponte do Porto, light energy and water temperature as the most significant system state variables.

RESULTS

Dissolved oxygen analysis was performed calibrating the model (Figure 4) for the most relevant parameters (Vieira *et al.*, 1996). Eutrophication model was calibrated for *chlorophyll-a* using data obtained from field survey in six sampling points (Figure 5). Adopted model parameters fall in common default ranges stated in similar studies (ICIM,1992).

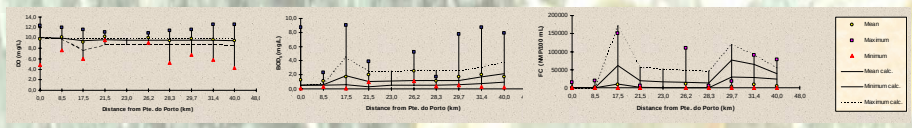

Figure 4 - Model Calibration (DO, BOD_5, FC)

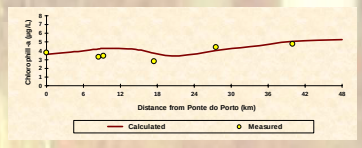

Figure 5 - Eutrophication Model Calibration

Result analysis was carried out in order to assess (Vieira *et al.*, 1997):

- The present water quality in this river reach, considering the existent pollutant;
- The effects of Braga WWTP efficiency at the intake planned location, for different flow regimes;
- The effects of flow regime variations on river water quality, in case of water flow abstraction maximum value at Areias de Vilar, and the consequent trophic state downstream;
- The influence of light energy and water temperature on *chlorophyll-a* concentration in order to analyse the eutrophication vulnerability of the aquatic system (Vieira *et al.*, 1998).

An example of the results obtained for simulated scenarios is shown in Figure 6, where *chlorophyll-a* spatial distribution under frequent dry-weather conditions , for the scenario ES 6, is presented.

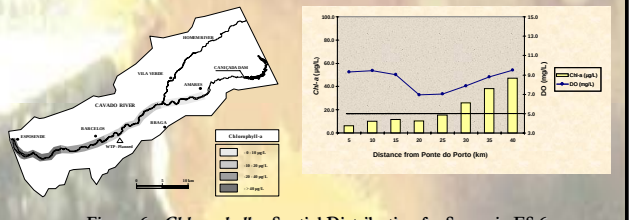

Figure 6 - *Chlorophyll-a* Spatial Distribution for Scenario ES 6

CONCLUSIONS

- Results of the model simulations show that the selected quality criteria for BOD and FC are violated in planned WTP site and in Barcelos region for some critical conditions related to the eventual rupture in Braga WWTP operation.
- Low-flow conditions are more severe to BOD concentrations, while wet-weather periods appears to be more critical for FC bacteria.
- High level of quality control of Braga WWTP as well as construction of Barcelos WWTP seems to be the best way to achieve the desired water quality standards.
- Braga WWTP failure seems to be the major factor for river water eutrophication, even when other nutrient sources are considered.

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